PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	10/810,452
Filing Date:	03/26/2004
Applicant:	Sehat Sutardja
Group Art Unit:	2838
Examiner:	Bao Q. Vu
Title:	VOLTAGE REGULATOR
Attorney Docket:	MP0467

BRIEF FOR APPELLANT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Appeal is from the decision of the Patent Examiner dated November 22, 2006, rejecting Claims 1, 4-11 and 14-29, which are reproduced as an Appendix to this Appeal Brief.

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I. Real Party in Interest

The entire interest in the present application, and the invention to which it is directed, was assigned from the inventors to Marvell Semiconductor Inc. at Reel 015159, Frame 0454, from Marvell Semiconductor Inc. to Marvell International Ltd. at Reel 015157, Frame 0923, and from Marvell International Ltd. to Marvell World Trade Ltd. at Reel 015790, Frame 0156.

II. Related Appeals and Interferences

The Appellants' legal representative and assignee do not know of any other appeals or interferences which will directly affect, or be directly affected by, or have a bearing on the Board's decision in this Appeal.

III. Status of Claims

The present application contains claims 1, 4-11 and 14-29, all of which are currently pending and form the basis for this Appeal.

IV. Status of Amendments

No amendments or responses were filed subsequent to Final Office Action dated November 22, 2006 other than the Notice of Appeal.

V. Summary of the Claimed Subject Matter

Switching regulators are widely used to provide voltage regulation in electronics sub-systems. A switching regulator may generate an output voltage by generating a pulse output from an input voltage. The pulse output is generally filtered by a low pass filter to generate a DC output voltage. The amplitude of the DC output voltage may be regulated by varying the pulse

width of the pulses that comprise the pulse output or controlling the on-time or the off-time of the pulse output.

A significant portion of power loss in a switching regulator occurs in the power switches that generate the pulse output from the input voltage. The power switch losses may be divided between conduction losses and switching losses. As the pulse width decreases in proportion to the switching frequency of the pulse output, the switching losses may increase relative to the conduction losses. In addition, at narrower pulse widths such as a 10% duty cycle, maintaining regulation of the output voltage may become more difficult resulting in increased error in the output voltage.

Figure 1A of Applicant's specification shows an exemplary conventional voltage regulator 10 for converting an input voltage to an output voltage Vout. A conduction switch 12 and freewheeling switch 14 may convert the input to a pulse output. For example only, the input voltage can be 12 Volts and the output voltage can be 1.2 Volts.

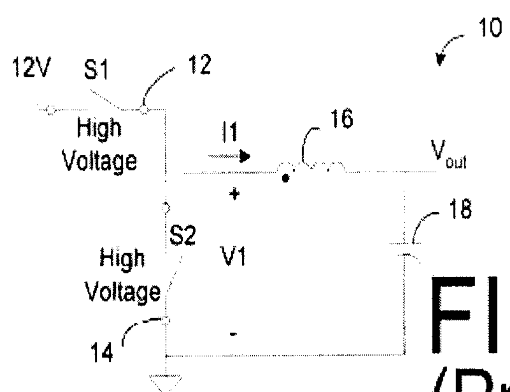


FIG. 1A
(Prior Art)

The conduction switch 12 and freewheeling switch 14 are generally selected to be **high voltage devices to withstand the entire input voltage**.

The pulse output may be filtered by an output inductor 16 and output capacitor 18 to form

Vout. Figure 1B of Applicant's specification shows waveforms associated with the conventional voltage regulator 10. Waveform 20 shows the operating state of the conduction switch 12. Waveform 22 shows the voltage V1 across the freewheeling switch 14. Voltage V1 may typically have a rise time and a fall time of about 10 nsec. The rise time and fall time are typically limited by the type of switches used for the conduction switch 12 and the freewheeling switch 14. The switching losses may increase as the rise time and fall time increase. Waveform 24 shows the current I1 flowing through the output inductor 16. As the pulse width continues to decrease, switching losses become a greater proportion of the total power losses.

Alternate prior art voltage regulators are also described in Qian U.S. Pat. No. 6,512,352. In a prior art circuit in FIG. 2 of Qian, Qian discloses a circuit that is similar to Applicant's claimed circuit:

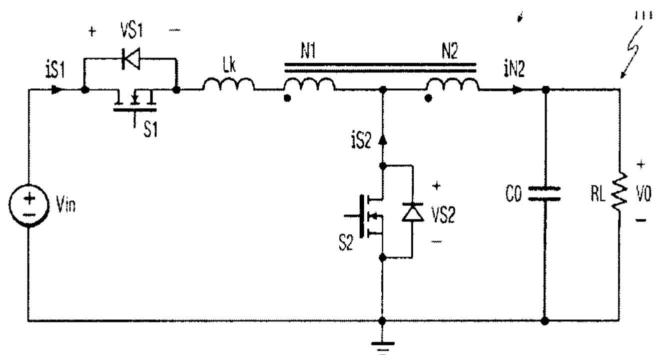


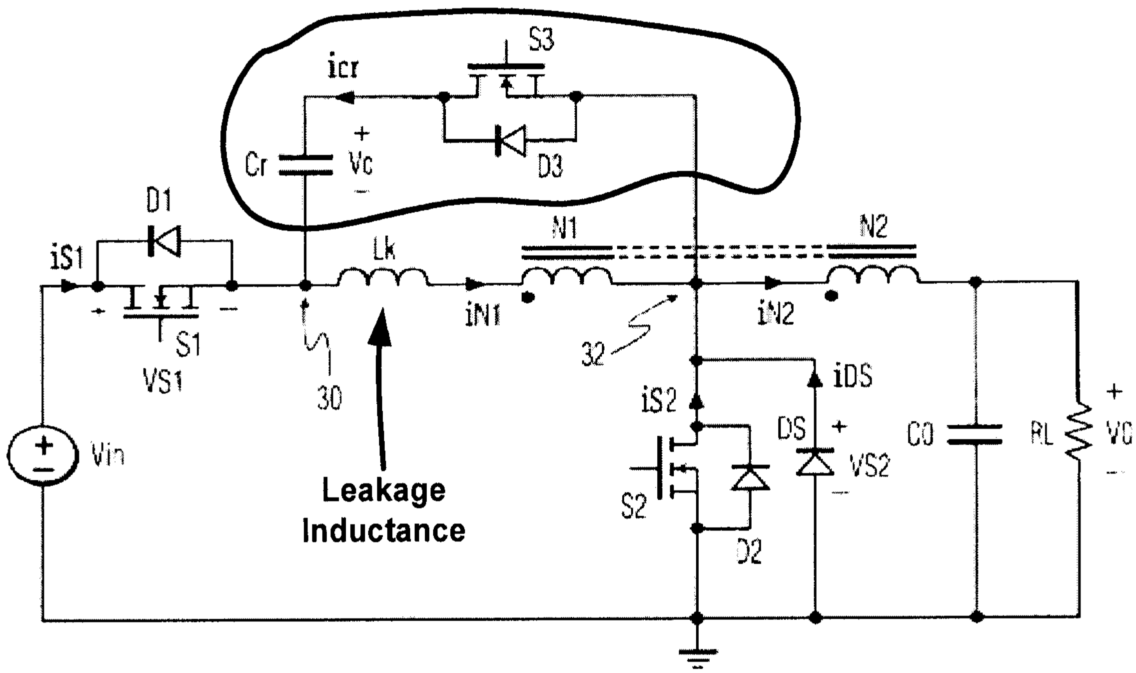
FIG. 2
PRIOR ART

Primary differences between Applicant's claimed circuit and this circuit include:

1. A different type of coupled inductor in that the coupled inductor has a coefficient of coupling that is at least 0.99; and

2. The turns ratio of the coupled inductor is at least 2.

The improvement disclosed by Qian in FIG. 4 is set forth below:



Qian essentially added the diode DS and the other circled components to the prior art circuit of FIG. 2.

Briefly, both FIGs. 2 and 4 of Qian '352 are directed towards solving problems associated with leakage inductance L_k associated with a coupled inductor that is not tightly coupled. To that end, Qian includes a circuit **<u>(that is circled above in FIG. 4)</u>** to compensate for the leakage inductance L_k of the coupled inductors in the prior art circuit of FIG. 2.

Applicant used a tightly coupled inductor having a coefficient greater than or equal to 0.99 to reduce the stress on the switches. Applicant also employs the turns ratio to further reduce the voltage demands on the switches, A voltage regulator 30 in FIG. 2A of Applicant's application supplies power to one or more devices such as high-speed drivers and other electronic devices. A conduction switch 32 may switch between an on-state and an off-state at a switching frequency to apply the input voltage to a coupled inductor 36. During the off-time,

the entire input voltage may be impressed across the conduction switch 32. Therefore the conduction switch 32 should have a withstanding voltage that is greater than the input voltage.

A freewheeling switch 34 may provide a path for current flowing in the coupled inductor 36 when the conduction switch 32 is in the off-state. Due to the operation of the coupled inductor 36, less than the entire input voltage is impressed across the freewheeling switch 34 during operation of the voltage regulator 30. Thus, the freewheeling switch 34 may have a withstanding voltage less than the input voltage.

The current flowing through the coupled inductor 36 may be filtered by an output capacitor 38 to form V_{out}. A drive signal generator 31 may generate a drive signal to control the conduction switch 32. The drive signal generator 31 may also generate a drive signal to control the freewheeling switch 34 if a controllable switch such as a FET is used as the freewheeling switch 34.

Switches that have a lower withstanding voltage typically have a lower Rds(on) or Vce(sat) than a switch with a comparable die size and a higher withstanding voltage. The lower Rds(on) or Vce(sat) may result in lower conduction losses. In addition, the switching losses may also be lower due to the lower voltage impressed across the freewheeling switch.

With a turns ratio of 2, the duty cycle of the voltage regulator is approximately two times greater than the duty cycle for the standard topology buck converter, current flowing through the coupled inductor 36a is approximately one-half the amplitude, and the voltage impressed across the drain-source of the freewheeling switch 34a is less than the voltage impressed across the drain-source of the standard topology buck converter. The voltage impressed across the drain-source of the freewheeling switch converter 34a is approximately:

$$Vds \cong (Vin - Vout) * \left(\frac{N2}{N1 + N2} \right) + Vout$$

In contrast, in a standard topology buck converter the voltage impressed across the drain-source of the freewheeling switch is approximately, $V_{ds} = V_{in}$.

The table set forth below provides support in the specification and drawings for independent Claims 1 and 11:

Claim 1	Specification
A voltage regulator for generating an output voltage from an input voltage, comprising:	At least paragraph [0016] and FIGs. 2A-4.
at least one coupled inductor **36** including a first winding **N1** and a second winding **N2** each having a polarity, the first winding **N1** and the second winding **N2** connected in series to form a common node and such that the first winding **N1** and the second winding **N2** have the same polarity, the first winding and the second winding having a coefficient of coupling greater than or equal to 0.99;	At least paragraphs [0016] and [0023] and FIGs. 2A, 2C, 4.
a conduction switch **32** having an on-state and an off-state, to controllably conduct the input voltage to the at least one coupled inductor **36** at a switching frequency; and	At least paragraph [0016] and FIGs. 2A, 2C, 4.
a freewheeling switch **34** having an on-state and an off-state, in communication with the common node of the at least one coupled inductor **36** to provide a path for current when the conduction switch is in the off-state,	At least paragraph [0016] and FIGs. 2A, 2C, 4.
wherein the first winding has a number of turns N1, the second winding has a number of turns N2 and a turns ratio N1/N2 is at least two.	At least paragraph [0021] and FIGs. 2A, 2C, 4.

Support for independent Claim 11:

Claim 11	Specification
A voltage regulator for generating an output	At least paragraph

voltage from an input voltage, comprising:	[0016] and FIGs. 2A-4.
at least one coupled inductor **36** including a first winding **N1** and a second winding **N2** each having a polarity, the first winding **N1** and the second winding **N2** connected in series to form a common node and such that the first winding **N1** and the second winding **N2** have the same polarity, the first winding **N1** and the second winding **N2** having a coefficient of coupling greater than or equal to 0.99;	At least paragraphs [0016] and [0023] and FIGs. 2A, 2C, 4.
means for conduction switching **32** having an on-state and an off-state, to controllably conduct the input voltage to the at least one coupled inductor **36** at a switching frequency; and	At least paragraph [0016] and FIGs. 2A, 2C, 4.
means for freewheeling switching **34** having an on-state and an off-state, in communication with the common node of the at least one coupled inductor **36** to provide a path for current when the conduction switching means **32** is in the off-state,	At least paragraph [0016] and FIGs. 2A, 2C, 4.
wherein the first winding has a number of turns N1, the second winding has a number of turns N2 and a turns ratio N1/N2 is at least two..	At least paragraph [0021] and FIGs. 2A, 2C, 4.

VI. Grounds of Rejection to be Reviewed on Appeal

The final Office Action presents four grounds of rejection for review in this Appeal:

1. Claims 1, 4, 5, 6, 9, 11, 14, 15, 16, 19, 21 and 23 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Qian (U.S. Pat. No. 6,512,352) in view of Lu et al (U.S. Pat. No. 5,636,107). This rejection is respectfully traversed.

2. Claims 7 and 17 are rejected under 35 U.S.C. § 103(a) as being unpatentable over

Qian in view of Lu et al and further in view of Beckman et al. (U.S. Pat. No. 6,184,666). This rejection is respectfully traversed.

3. Claims 10, 22, 20, 24 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Qian in view of Lu et al and further in view of Yang et al. (U.S. Pat. No. 6,404,175). This rejection is respectfully traversed.

4. Claims 8, 18 and 25-29 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Qian in view of Lu et al and further in view of Dwelley et al. (U.S. Pat. No. 6,166,527). This rejection is respectfully traversed.

VII. Arguments

A. The Examiner's rejection of Claims 1, 4, 5, 6, 9, 11, 14, 15, 16, 19, 21 and 23 under 35 U.S.C. § 103(a) as being unpatentable over Qian (U.S. Pat. No. 6,512,352) in view of Lu et al (U.S. Pat. No. 5,636,107) is improper and should be withdrawn.

1. Claim 1.

With respect to Claim 1, both Qian and Lu fail to show, teach or suggest a coupled inductor having first and second windings, wherein the first winding and the second winding have a coefficient of coupling that is greater than or equal to 0.99.

The Qian reference **teaches away** from using a tightly coupled inductor. As best understood by Applicant, Qian addresses the situation where the coupled inductors have a **SIGNIFICANT** leakage inductance (represented by L_k) that causes **HIGH** voltage spikes across the switches. **The Examiner admits that Lu does not address this issue.**

Qian presents a prior art circuit in FIG. 2 and shows leakage inductance L_k of the coupled

inductor. FIG. 2 is set forth below with the leakage inductance identified using an arrow:

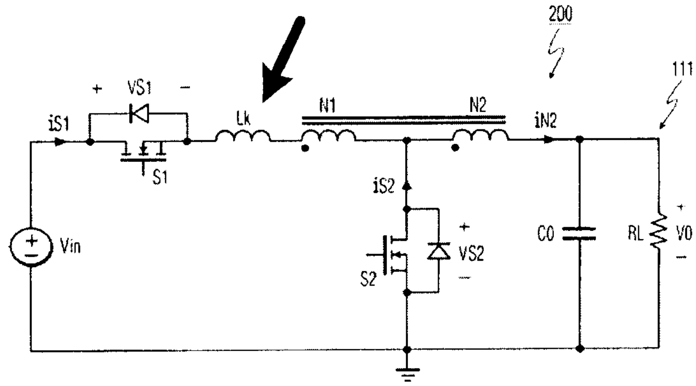
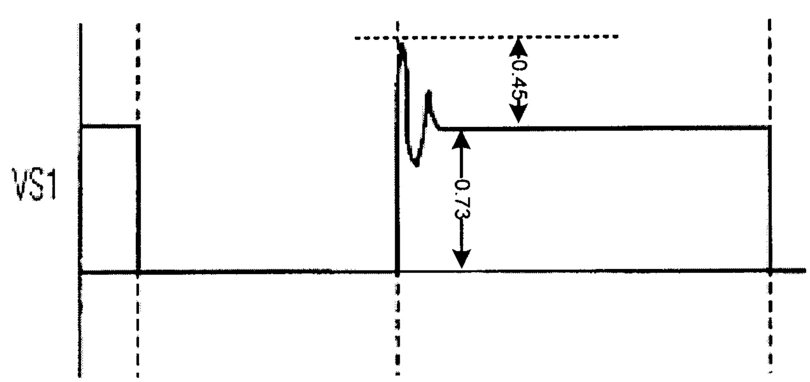


FIG. 2
PRIOR ART

L_k is not a discrete element in the circuit of prior art FIG. 2 but is an equivalent element representing leakage inductance L_k of the coupled inductors. In FIG. 3e, Qian shows the voltage spikes that occur in the prior art FIG. 2 as a result of the significant leakage inductance L_k in the prior art circuit of FIG. 2.

In FIGs. 3a-3f of Qian, large voltage spikes due to the leakage inductance L_k are shown that occur in the prior art circuit of FIG. 2 when the switch S1 is turned off and S2 is turned on. The voltage spikes swing to a voltage that is approximately 160% of the nominal voltage value. FIG. 3e (with added notations) of Qian is set forth below:



Qian states in Col. 2, lines 55-63:

> One disadvantage of circuit 200 is that a high voltage spike occurs across switch S1 when S1 turns off (e.g., at time t2, See FIG. 3E) **because the leakage energy of winding N1 cannot be transferred to winding N2. The leakage energy in L_k charges the output capacitance (not shown) of S1 through conducting switch S2 which causes a high voltage stress across S1.** As a result, a high voltage rated MOSFET switch must be used in the circuit 200 which significantly increases the power loss and reduces the efficiency.

As best understood by Applicant, the voltage swing that occurs as a result of the leakage inductance L_k appears to support the idea that while the inductors of Qian may be coupled, they are not <u>**tightly**</u> coupled in a manner as claimed. Furthermore, the switch S1 in prior art FIG. 2 of Qian must be able to withstand 160% of the input voltage rather than merely the input voltage as in Applicant's voltage regulator.

In response to these arguments, the Examiner alleges that Applicant has misconstrued the prior art by relying on prior art description of FIG. 2 in Qian. **See Final Office Action**, page 5 at paragraph 7. The Examiner alleges that "the prior art description is different than that of the invention being claimed in Qian." Applicant respectfully asserts that the Examiner is **incorrect** on this point.

The circuit in FIG. 4 of Qian <u>**also**</u> uses all of the elements of the prior art circuit of FIG. 2 – including the coupled inductors with leakage inductance L_k. Therefore the description of FIG. 2 is equally applicable to FIG. 4 – contrary to the Examiner's assertion.

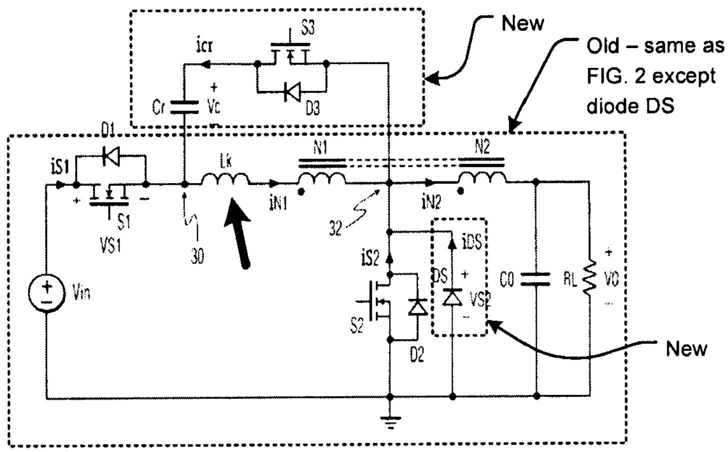


FIG. 4

There is **no discussion** in Qian that the coupled inductors in FIG. 4 are different than those in the prior art circuit of FIG. 2. In fact, Qian uses the exact same symbols.

Furthermore, the **whole point** of the improvement of Qian was to add the additional components to the prior art circuit of FIG. 2 **to compensate** for the leakage inductance L_k and to handle the voltage spikes that arise in the prior art circuit of FIG. 2.

In paragraphs 8-10 of the Final Office Action dated November 22, 2006, the Examiner incorrectly alleges that Applicant's response amounts to general allegations and fail to clearly point out patentable novelty. Applicant has clearly and consistently pointed out the reasons why **Qian does not disclose tightly coupled inductors** as expressly set forth in Claim 1.

Applicant respectfully asserts that it is the Examiner that has failed to explicitly set forth a proper basis for the rejection. In the latest rejection, the Examiner **does not address** the claim limitation that the coupled inductors have a coupling coefficient of at least 0.99. While rejecting Claim 1 based on Qian at various times under 35 U.S.C §102(b) or §103, the Examiner has consistently failed to address Applicant's arguments that Qian cannot and does not disclose tightly coupled inductors having a coupling coefficient of at least 0.99. At various points, the

Examiner has argued that this limitation is disclosed in Qian or that it is inherent in Qian (citing secondary references to support inherency). None of these positions can be supported.

There is no explicit description of the coupling coefficient in Qian. The Examiner tacitly admits this point in the Remarks of the August 15, 2005 Office Action. There, the Examiner relies upon inherency for this limitation and then relies upon the Stratton reference (U.S. Pat. No. 4,273,051) to support inherency, as will be discussed further below.

The claimed coupling coefficient is not inherent in Qian. As described above, Qian is directly to solving problems associated with coupled inductors having significant leakage inductance and thus **teaches away** from the use of coupled inductors with the claimed coefficient of coupling. Therefore, this limitation is not inherent in Qian for at least this reason.

In prior rejections, the Examiner asserted that having a coefficient of coupling greater than or equal to 0.99 "is an inherent feature of the most basic principle of all transformer design". To support this conclusion, the Examiner has relied upon either the Stratton reference or a textbook by Hayt and Kemmerly, "Engineering Circuit and Analysis" at pages 442-443.

The textbook **does not support** the Examiner's position for at least two reasons. First, the textbook states that "an ideal transformer is a useful approximation of a **very tightly** coupled transformer in which the coefficient of coupling is almost unity and both the primary and secondary inductive reactances are extremely large in comparison with the terminating impedances." (Emphasis Added). This statement **does not** support the conclusion that **ALL** transformer designs include tightly coupled transformers. Rather, this statement supports the idea that **WHEN** a tightly coupled transformer **IS** used, an ideal transformer is a reasonable approximation.

As was discussed above, the inductors in Qian do not appear to be tightly coupled as

shown in FIGs. 2, 3e and 4 of Qian. Therefore, **since** Qian does not appear to include tightly coupled inductors, the ideal transformer is **not** necessarily a useful approximation.

In another Office Action on August 15, 2005, the Examiner relied upon the Stratton reference to supply this teaching. **See** Remarks, Office Action August 15, 2005. Applicant correctly pointed out that **Stratton expressly recommends coefficients of coupling K in the range of 0.5 to 0.9**. See Col. 5, lines 48-51. Thus, Stratton teaches away from the claimed invention. In addition, Stratton also supports the idea that there are a wide variety of other suitable coefficients of coupling in voltage regulators.

The fact that a certain characteristic **may occur or be present** in the prior art reference is not sufficient to establish inherency of that characteristic. ***In re Rijckaert***, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993) (emphasis added). The Federal Circuit has clearly stated that:

> To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is **necessarily** present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities.'

In re Robertson, 49 USPPQ2d 1949, 1950-1951 (Fed. Cir. 1999) (emphasis added).

"In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic **<u>necessarily</u>** flows from the teachings of the applied prior art." ***Ex Parte Levy***, 17 USPQ2d 1461 (Bd. Pat. App. & Inter. 1990) (emphasis original). Therefore, the coupling coefficient of that is greater than or equal to 0.99 must **necessarily flow** from the teachings of the Qian reference. **Applicant respectfully asserts that this is not the case here**.

Applicant respectfully asserts that Qian **<u>teaches away</u>** from using tightly coupled inductors. Furthermore, tightly coupled inductors are **<u>not inherent</u>** in the Qian disclosure.

Therefore, the Examiner has failed to properly support his rejection under 35 U.S.C. §103 for at least these reasons.

There are additional reasons why Claim 1 is novel and nonobvious. As admitted by the Examiner, Qian fails to show, teach or suggest the first winding has a number of turns N1, the second winding has a number of turns N2, and a turns ratio N1/N2 is set to a predetermined value of at least two. The use of the claimed turns ratio provides particular advantages in the claimed circuit as will be described below.

Other than showing a 2:1 turns ratio of a transformer, the circuit of Lu et al. has **no other similarity to the circuit shown in Qian**. Applicant respectfully asserts that the Examiner is using hindsight in making this combination.

The alleged motivation is to "provide a simplistic approach to control the output voltage and output current induced in the secondary by changing the turns ratio of the transformer." This brief explanation falls far short of the type of **explicit analysis** that is required by the Supreme Court in **KSR Int'l v. Teleflex Inc.**, 550 U.S. ____ (2007). This explicit analysis and reasoning must be supplied by the Examiner absent an express teaching or suggestion in the references for making the combination. **Id.** The Examiner's failure to provide a proper basis for picking and choosing prior art references is fatal to his obviousness arguments.

In prior rejections, the Examiner also alleged that there was no particular advantage to the use of the claimed turns ratio. As will be described below, there are significant unexpected advantages to using the turns ratio in this circuit. Applicant described the particular purpose and advantages of the claimed turns ratio in this particular circuit in the specification as filed:

> **[0021]** ... With a turns ratio of 2, the duty cycle of the voltage regulator is approximately two times greater than the duty cycle for the standard topology buck converter, the current flowing through the coupled inductor 36a is

approximately one-half the amplitude, and the voltage impressed across the drain-source of the freewheeling switch 34a is less than the voltage impressed across the drain-source of the standard topology buck converter. The voltage impressed across the drain-source of the freewheeling switch 34a is approximately, $Vds \cong (Vin - Vout) * \left(\frac{N2}{N1 + N2} \right) + Vout$. In contradistinction, in a standard topology buck converter the voltage impressed across the drain-source of the freewheeling switch is approximately, $Vds \cong Vin$.

[0022] Therefore, the freewheeling switch 34a may be selected to have a lower withstanding voltage, Vds; and by using a similar die size to what a standard topology switch would use, the Rds(on) for the freewheeling switch 34a may also be lower.

Therefore, the use of the tightly coupled inductors simplifies the voltage regulator circuit. Furthermore, using the claimed turns ratio may allow the freewheeling switch to have a lower withstanding voltage. By using a similar die size to what a standard topology switch would use, the Rds(on) for the freewheeling switch may also tend to be lower.

Claim 1 is therefore allowable over the prior art of record. Claim 11 is allowable for at least similar reasons as Claim 1. The remaining Claims are either directly or indirectly dependent upon allowable Claims 1 and 11 and are therefore allowable for at least similar reasons.

B. The Examiner's rejection of Claims 7 and 17 under 35 U.S.C. § 103(a) as being unpatentable over Qian in view of Lu et al and further in view of Beckman et al. (U.S. Pat. No. 6,184,666) is improper and should be withdrawn.

Applicant incorporates the arguments set forth above in section A and respectfully asserts that Claims 7 and 17 are allowable for at least similar reasons as those set forth for Claim 1 and 11.

C. The Examiner's rejection of Claims 10, 22, 20, 24 under 35 U.S.C. § 103(a) as being unpatentable over Qian in view of Lu et al and further in view of Yang et al. (U.S. Pat. No. 6,404,175) is improper and should be withdrawn.

Applicant incorporates the arguments set forth above in section A and respectfully asserts that Claims 10, 22, 20 and 24 are allowable for at least similar reasons as those set forth for Claim 1 and 11.

D. The Examiner's rejection of Claims 8, 18 and 25-29 under 35 U.S.C. § 103(a) as being unpatentable over Qian in view of Lu et al and further in view of Dwelley et al. (U.S. Pat. No. 6,166,527) is improper and should be withdrawn.

Applicant incorporates the arguments set forth above in section A and respectfully asserts that Claims 8, 18 and 25-29 are allowable for at least similar reasons as those set forth for Claim 1 and 11.

In addition to the foregoing arguments, with respect to Claim 26, none of the references show, teach or suggest using a freewheeling switch that has a lower withstanding voltage than a conduction switch. With respect to Claim 27, none of the references show, teach or suggest the freewheeling switch and the conduction switch are Field Effect Transistors and the freewheeling switch has a lower Rds(on) than the conduction switch

Switches that have a lower withstanding voltage typically have a lower Rds(on) or Vce(sat) than a switch with a comparable die size and a higher withstanding voltage. The lower Rds(on) or Vce(sat) may result in lower conduction losses. In addition, the switching losses may also be lower due to the lower voltage impressed across the freewheeling switch.

Therefore, Claims 26 and 27 are allowable for at least these reasons. Claims 28 and 29 are allowable for at least similar reasons as Claims 26 and 27.

VIII. Conclusion

For the reasons presented above, the rejections of the claims are not properly founded and should be reversed.

Respectfully submitted,

HARNESS, DICKEY & PIERCE, P.L.C.

Date: 5/21/07

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APPENDIX A

Claim Listing:

1. (Previously Presented) A voltage regulator for generating an output voltage from an input voltage, comprising:

at least one coupled inductor including a first winding and a second winding each having a polarity, the first winding and the second winding connected in series to form a common node and such that the first winding and the second winding have the same polarity, the first winding and the second winding having a coefficient of coupling greater than or equal to 0.99;

a conduction switch having an on-state and an off-state, to controllably conduct the input voltage to the at least one coupled inductor at a switching frequency; and

a freewheeling switch having an on-state and an off-state, in communication with the common node of the at least one coupled inductor to provide a path for current when the conduction switch is in the off-state,

wherein the first winding has a number of turns N1, the second winding has a number of turns N2 and a turns ratio N1/N2 is at least two.

Claims 2-3 (Cancelled).

4. (Original) The voltage regulator of Claim 3 wherein the turns ratio is approximately two.

5. (Original) The voltage regulator of Claim 1 wherein the coupled inductor is formed on a single core of magnetic material.

6. (Original) The voltage regulator of Claim 1 further comprising an output capacitor in communication with the at least one coupled inductor to filter the output voltage.

7. (Original) The voltage regulator of Claim 1 wherein the conduction switch includes parallel independently controlled switches.

8. (Original) The voltage regulator of Claim 1 further comprising a multi-level gate drive to control the conduction switch.

9. (Original) The voltage regulator of Claim 1 wherein the freewheeling switch is selected from a group consisting of uni-directional switches, bi-directional switches, diodes, rectifiers, synchronous rectifiers, FETs, NMOS, PMOS, BJTs, and IGBTs.

10. (Original) The voltage regulator of Claim 1 further comprising at least another voltage regulator connected in parallel with the voltage regulator.

11. (Previously Presented) A voltage regulator for generating an output voltage from an input voltage, comprising:

at least one coupled inductor including a first winding and a second winding each having a polarity, the first winding and the second winding connected in series to form a

common node and such that the first winding and the second winding have the same polarity, the first winding and the second winding having a coefficient of coupling greater than or equal to 0.99;

means for conduction switching having an on-state and an off-state, to controllably conduct the input voltage to the at least one coupled inductor at a switching frequency; and

means for freewheeling switching having an on-state and an off-state, in communication with the common node of the at least one coupled inductor to provide a path for current when the conduction switching means is in the off-state,

wherein the first winding has a number of turns N1, the second winding has a number of turns N2 and a turns ratio N1/N2 is at least two..

Claims 12-13 (Cancelled).

14. (Original) The voltage regulator of Claim 13 wherein the turns ratio is approximately two.

15. (Original) The voltage regulator of Claim 11 wherein the coupled inductor is formed on a single core of magnetic material.

16. (Original) The voltage regulator of Claim 11 further comprising means for filtering in communication with the at least one coupled inductor to filter the output voltage.

17. (Original) The voltage regulator of Claim 11 wherein the conduction switching means includes parallel independently controlled switches.

18. (Original) The voltage regulator of Claim 11 further comprising a multi-level gate drive to control the conduction switching means.

19. (Original) The voltage regulator of Claim 11 wherein the freewheeling switching means is selected from a group consisting of uni-directional switches, bi-directional switches, diodes, rectifiers, synchronous rectifiers, FETs, NMOS, PMOS, BJTs, and IGBTs.

20. (Original) The voltage regulator of Claim 11 further comprising at least another voltage regulator connected in parallel with the voltage regulator.

21. (Original) The voltage regulator of Claim 1 wherein the conduction switch is selected from a group consisting of Field Effect Transistors (FETs), NMOS, PMOS, Bipolar Junction Transistors (BJTs), and Integrated Gate Bipolar Junction Transistors (IGBTs).

22. (Original) The voltage regulator of Claim 10 further comprising a phase generator in communication with each of the voltage regulators to control a phase sequence of the voltage regulators.

23. (Original) The voltage regulator of Claim 11 wherein the means for conduction switching is selected from a group consisting of Field Effect Transistors (FETs), NMOS, PMOS,

Bipolar Junction Transistors (BJTs), and Integrated Gate Bipolar Junction Transistors (IGBTs).

24. (Original) The voltage regulator of Claim 20 further comprising means for phase controlling in communication with each of the voltage regulators to control a phase sequence of the voltage regulators.

25. (Original) The voltage regulator of Claim 1 further comprising a controller to control the on-time of the conduction switch such that the output voltage is regulated to a predetermined amplitude.

26. (Original) The voltage regulator of Claim 1 wherein the freewheeling switch has a lower withstanding voltage than the conduction switch.

27. (Original) The voltage regulator of Claim 1 wherein the freewheeling switch and the conduction switch are Field Effect Transistors and the freewheeling switch has a lower Rds(on) than the conduction switch.

28. (Original) The voltage regulator of Claim 11 wherein the means for freewheeling switching has a lower withstanding voltage than the means for conduction switching.

29. (Original) The voltage regulator of Claim 11 wherein the means for freewheeling switching and the means for conduction switching are Field Effect Transistors and the means for freewheeling switching has a lower Rds(on) than the means for conduction switching.

APPENDIX B Evidence Appendix

There is no evidence being submitted with this appeal.

APPENDIX C

There are no related proceedings.